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INSTRUMENTS BRANCH OF THE METEOROLOGICAL OFFICE IN WAR AND PEACE

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SUPERINTENDENT OF INSTRUMENTS

Historical.—A separate branch " to deal with questions arising out of the supply of meteorological instruments for the Navy, observers on ships of the mercantile marine, Colonial Governments, and the stations of various kinds " was first constituted in the Meteorological Office, at 63 Victoria Street, at the beginning of October, 1905. Before then such questions had been dealt with by the Marine Branch. Mr. R. G. K. Lempfert took charge of the new Branch temporarily until Mr. E. Gold was specially appointed as the Superintendent of Instruments in 1906. In those days the work of the Branch appears to have been almost entirely concerned with questions of supply and the *First Report of the Meteorological Committee*, for 1905–6, when the staff of the whole Meteorological Office only numbered 52, records that the total expenditure on instruments in that financial year was £2,229 and that 1,018 instruments were supplied to the Navy, 747 to merchant ships and 58 to land stations. Ocean weather observations were considered of primary importance in those days.

On October 1, 1910, the Instruments Branch moved with the rest of the Headquarters of the Office to the new building at Exhibition Road, South Kensington. The staff of the Branch then numbered seven, the total staff of the Office being 74. In the 1914–8 war the annual expenditure on instruments rose steeply to a peak of £28,199, and more attention began to be paid to the development of new instruments, notably an aircraft psychrometer. Soon after 1919, when the Meteorological Office became attached to the Air Ministry, the Instruments Branch was designated by the short title M.O.4. After a relatively uneventful period of 15 years the Branch expanded very slowly to meet the increased demands arising in the rearmament period before the last war. In August, 1939, the staff of the Branch numbered 25 but facilities for research and development were still very limited.

The Branch remained at South Kensington until November, 1939, when it was evacuated to Wycliffe College, Stonehouse, Gloucestershire. Here, during

the war years, a large expansion took place to meet the needs of the Services and in 1941 it was found necessary to re-organise the Branch into two sections, the functions of which will be described later. At the end of August, 1945, M.O.4 moved to its present location at Headstone Drive, Harrow, where it occupies a floor space of 27,500 sq. ft. in the main building and in outbuildings. The main building is shared with the Marine and Climatological Branches.

General organization.—The work of the Instruments Branch at the present time divides into two main parts. One covers the scientific and technical aspects and the other the supply aspects of meteorological equipment. Each of these divisions is subdivided into smaller sections, the organization of which is shown in outline in the diagram on p. 123.

At the present time the staff of the Branch consists of 6 scientific and (temporary) technical officers, 19 experimental officers, 57 assistants and clerical staff and 46 of industrial grade. Many changes of staff have taken place in the past year and the peace-time establishment and organization is under review. The work of the Branch has changed appreciably since the end of the war, mainly because of the transfer of radio-sonde work from Kew, but it has not diminished appreciably, for the heavy war-time demands of the Services have given place to almost equally heavy peace-time demands for civil aviation and agriculture, for new projects such as the ocean weather ships and radar-wind stations, and from Dominions, Colonial and Foreign services.

Technical Section.—The work of this section includes research, design and development of instruments, test and inspection and the calibration of instruments for upper air measurements, including radio-sondes.

Research and development is, in the main, concentrated on the instrumental problems included in the research programme of the Meteorological Research Committee. These problems, which at present number about 50 and are of varying degrees of priority, fall into five main categories :—

(*a*) meteorological instruments for surface observations on land,

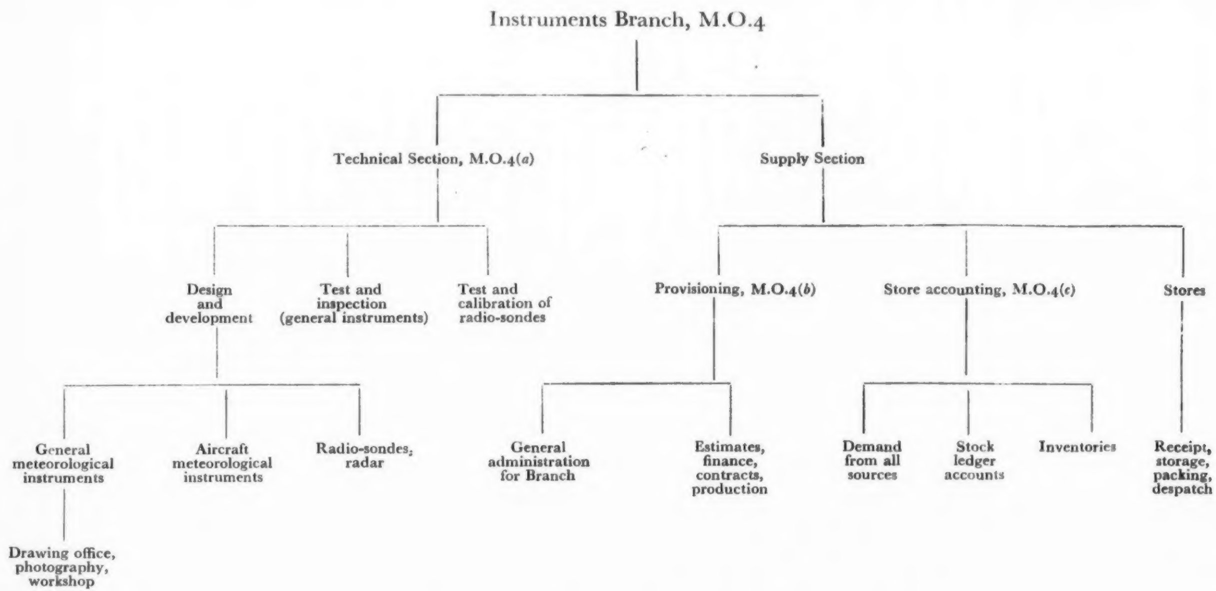
(*b*) marine meteorological instruments,

(*c*) meteorological instruments for use on aircraft,

(*d*) radio-sondes and associated ground equipment,

(*e*) the application of radar and electronic techniques.

In the problems involving radio applications the Branch is guided by a technical advisory panel of representatives from the Directorate of Communications Development, Ministry of Supply, the National Physical Laboratory and the Meteorological Office. The resources of Government scientific establishments such as the Telecommunications Research Establishment, the Royal Aircraft Establishment, the Research and Development Establishment at Cardington and the National Physical Laboratory are drawn upon to an appreciable extent, and in the development of meteorological instruments for aircraft there is close collaboration with the Meteorological Research Flight and with Professor G. M. B. Dobson of Oxford University. In many cases the development of an instrument is carried right through the research and experimental stages to the making of the prototype production model in the Branch ; in fact, when certain new instruments were required urgently during the war the Branch undertook small-scale production as well. In other cases,



GENERAL ORGANIZATION OF THE INSTRUMENTS BRANCH.

after the experimental stages have been passed, a contract is placed with a suitable firm of instrument makers for the development of the prototype production model. Close contact is kept with the manufacturers and much assistance is received from and given to them.

The experimental laboratories of the Branch are on the first floor of the main building at Harrow. Specimens of current designs of instruments are displayed in one of the larger rooms and another room is used for exhibiting instruments of historic interest. Instruments recently developed, or at present in process of development, include the radio-sonde Mk.II, the chronometric radio-sonde, the photo-electric frost-point hygrometer, the aircraft electrical-resistance psychrometer, the photo-electric visibility meter, the day-time cloud searchlight and the Bibby chronograph for recording wind velocity or rainfall. It is hoped that articles describing the development of some of these instruments will appear later. The equipment of the section includes two small wind tunnels (one of the open jet type) both of which were made in the Branch to the design of one of the officers. A lattice tower on the roof of the main building is used for service trials of anemometers. In a well equipped workshop in one of the outbuildings, the construction of prototype instruments and experimental apparatus is supervised by the senior instrument maker. There is also a drawing office and a photographic studio and darkroom. The preparation of detailed specifications and of instructions for installing, operating and maintaining equipment is an important part of the work. A disadvantage of the Harrow premises is the lack of outside space for field trials of equipment ; this has been overcome temporarily by the use of some ground at Northolt airport.

Testing and inspection is undertaken in several large rooms specially fitted up for this purpose on the ground floor at Harrow. All new instruments received from the makers and all instruments returned from outstations are examined and tested and, where necessary, calibrated. The equipment in the main test room, a view of which is reproduced in the photograph facing p. 128, includes decompression and low-temperature chambers, a humidity control cabinet and standard barometers. A smaller room contains apparatus for calibration of resistance thermometers and indicators of electrical psychrometers and frost-point hygrometers. Another room houses the balloon inflation and inspection apparatus. The assessment of damage of instruments returned from operational use is undertaken and arrangements made for their repair either in the Branch workshop or at the makers. The total number of instruments tested in 1946, excluding radio-sondes and balloons, was just under 50,000. This may be compared with the average number of 5,000 for the years about 1930 and with the peak figure of 61,360 in 1944. The total number of pilot and sounding balloons which passed through the test section during the war reached 2¼ millions.

Calibration of radio-sondes, which during the war was undertaken at Kew Observatory and Larkhill, was recently transferred to the Instruments Branch. The section dealing with this work is housed in a number of rooms on the ground floor. To deal with the rapidly increasing requirements of radio-sonde stations some new plant, including two Kelvinator "stratosphere" low-temperature and low-pressure cabinets, each capable of taking 64 temperature or pressure elements at a time, has been installed. In addition, several Kew-pattern calibration vessels and humidity chambers are in operation. A

photograph of the plant is reproduced in the photograph facing p. 129. At present all new radio-sondes are individually tested and calibrated in the Branch (over a pressure range of 1050 to 50 mb. and a temperature range of $+80^{\circ}$ to -90° F.) but it is hoped that the bulk of this work will eventually be undertaken by the makers. In April, 1947, the total number of radio-sondes calibrated was 1,150 and the output is increasing every month. In addition to the work on new instruments, recovered radio-sondes are examined and, if not too badly damaged, are reconditioned and re-calibrated.

Supply Section.—The work of maintaining supplies of equipment for Meteorological Office stations and for other services is divided into three sections covering the provision, issue and accounting, and storage of the equipment. The first two sections are mostly concerned with work of an administrative or clerical nature and are accommodated in offices on the second floor at Harrow. The stores section is housed in outbuildings, and in the basement of the main building.

Provisioning.—Estimates of Meteorological Office requirements of equipment and similar requirements for other services, including Dominions and Foreign Governments, are co-ordinated and arrangements are made to obtain the stocks to meet them. These arrangements include the placing of contracts and local purchase orders with manufacturers and the raising of requisitions on Government stores. In this work close liaison has to be maintained with the Finance, Contracts and Equipment Branches of the Air Ministry. It is also the responsibility of the section to see that the production of new equipment progresses satisfactorily. In 1946 the total expenditure on new instruments amounted to £170,600 ; the peak figure was reached in 1944 when the total was £225,134. In peace time some of the expenditure is offset by the sale of equipment to other services. The provisioning section also prepares the " Priced vocabulary of meteorological stores " and assists in the preparation of the authorised establishments of equipment for the various types of Meteorological Office stations.

Before leaving the subject of provisioning it is appropriate to acknowledge here the special efforts made during the war, often in the face of extreme difficulties, by the many firms of instrument makers in the supply of the large number of instruments ordered by the Office. It would need a very long list to name them all but it may be of interest to mention that eight firms have supplied the Office during both the world wars. Moreover, two very old established firms have, in fact, been supplying the Meteorological Office throughout the 92 years of its existence.

Store accounting.—This subsection deals with all incoming demands for equipment and arranges for its issue and accounting. As already indicated, demands are received not only from the stations of the Meteorological Office but also from other Government Departments, from Dominions and Foreign Services and from voluntary observers. A large proportion of issues, therefore, have to be arranged on repayment terms. The number of individual demands dealt with in 1946 was 8,968 which may be compared with the peak figure of 12,470 reached in 1944. The store accounting system consists essentially of the keeping of stock ledgers under various headings and, in the case of equipment issued to Meteorological Office stations and to observing ships of the Merchant Navy, in the maintenance and annual checking of inventories.

Stores.—The whole of the basement at Harrow is used for storage and there are also storerooms in the outbuildings and the sub-basement. The total storage space at present available amounts to about 13,500 sq. ft. but additional outbuildings are planned to accommodate stores which at present have to be left out in the open. Store-keeping is facilitated by a tally-card system in which current stocks are recorded. A stores reference number is allocated to each different item ; the total number of stores now handled is about 3,000, about one half of which is radio-sonde and radar equipment and the other half general meteorological stores. A very large proportion of the stores despatched is for destinations outside the British Isles. Recent large consignments, for example, have included shipments to Australia, New Zealand, Argentina, the Netherlands, Belgium, and east Africa, as well as to the widely scattered overseas stations of the Meteorological Office.

From what has been said it will be seen that the work of the Instruments Branch covers a wide field. New work which is now being undertaken includes arranging for the provision of much of the equipment of the ocean weather ships not only meteorological equipment but a dozen or more other categories of stores ranging from engine-room stores to food and water. In fact, of the many odd things which the Branch is now called upon to supply, " shoes and ships and sealing-wax " are almost literally typical examples. In concluding this account the writer wishes to acknowledge the devoted service of the members of the staff of the Instruments Branch, both temporary and permanent, during and since the war. At times, especially in the period leading up to D-day, very heavy demands at short notice strained the organization to the utmost, but the extra efforts which were required from all grades of the staff on such occasions were made without demur.

UNSOLVED PROBLEM OF CLIMATIC CHANGE

BY C. E. P. BROOKS, D.SC.

Part I. Facts

Twenty years ago I discussed* about fifty different theories of the causes of geological changes of climate, not one of which was completely satisfactory. Since then many more have been added to the list, including the notable contribution of Sir George Simpson, and it seems desirable to review the position.

Table I gives a brief summary of the geological eras, their approximate dates and their prevailing climate in middle and high latitudes. This table shows that conditions similar to or more severe than the present, with large ice sheets and frozen poles, are highly exceptional ; for at least nine tenths of geological time the earth seems to have enjoyed a mild equable climate up to high latitudes. The climate during these genial periods was not uniform ; as Sir George Simpson has emphasised, on a globe warmed by the sun thermal zones must always have existed, but the contrast between equator and poles does seem to have been much less than now, and for much of the time ice was probably unknown anywhere on the earth's surface. This halcyon existence has been rudely interrupted at least four times by the spreading out of great ice sheets. One of the first occurred in the Algonkian, near the beginning of the record, and effectually disposes of all theories of a cooling earth. The second

* BROOKS, C. E. P. ; Climate through the ages. London, 1926.

occurred about 500 million years ago, more or less simultaneously in North America, India, South Africa and Australia. The third, the famous Permo-Carboniferous ice age, was very remarkable ; ice spread out over enormous areas in South America, South Africa, India and Australia, reaching the sea in all these countries. Ice sheets extended on either side of the equator, while further north a rich vegetation flourished, reaching high latitudes in Spitsbergen. This ice age has been one of the great problems of geology since its discovery. The latest ice age, the Quaternary or Pleistocene, began less than a million years ago, and as late as 20,000 B.C. ice still covered great areas of Europe and North America ; this ice age may not yet be over.

TABLE I.—GEOLOGICAL SUCCESSION AND CLIMATE

Age of base	Formation	Climate of middle latitudes
million years		
1	Quaternary (Pleistocene)	Glacial
70	Tertiary	Mainly subtropical or temperate, becoming cold at close
110	Cretaceous	Cooler
140	Jurassic	Tropical to subtropical
190	Triassic	Tropical to subtropical
225	Permian	Cool, glacial at first
270	Carboniferous	Temperate at first, becoming glacial at close in southern hemisphere
310	Devonian	Tropical to subtropical
340	Silurian	Cooler
390	Ordovician	Tropical to subtropical
500	Cambrian	Glacial at first, becoming subtropical
—	Pre-Cambrian	At least one period of glaciation

The last two ice ages at least were not single events ; the ice advanced and retreated several times. It is convenient to distinguish these main advances as " glaciations ", while the whole period is known as an " ice age ". In the Quaternary era there were four main glaciations in Europe and probably also in North America ; these have been given local names in different areas but the Alpine classification designed by Penck and Bruckner—Gunz, Mindel, Riss, Wurm—has become a sort of world-wide standard. The interglacials between Gunz and Mindel and between Riss and Wurm were relatively short, but the Mindel-Riss interglacial was much longer, of the order of 250,000 years. Outside Europe and North America, the number of known glaciations varies, but in many regions only two have been found. This may be because remains of earlier extensions of the ice have been destroyed or buried, but there is some evidence that in parts of the world, especially in the tropics, glaciation did not begin until relatively late, possibly the Riss. This lag may be due to the time required for the general cooling of the oceans by mel -water from the earlier ice sheets. It is becoming evident that the latest glaciation, the Wurm of the

Alps and the Wisconsin of North America, was practically contemporaneous over the whole world.

Each of these glaciations was again divided into two or three maxima separated by interstadial periods, and the concluding stages of the Wurm have been marked by a series of rapid retreats, separated by stand-stills or re-advances. The Wurm was formerly considered to have ended in Europe about 6,900 B.C., when the ice sheet, having retreated to Scandinavia, split into two small remnants, but a more natural view, climatically, is that favoured by Dr. H. Godwin and now generally accepted, which places the end of the late glacial period at about 8,500 B.C., when the tundra of north-western Europe was extensively replaced by forest. During the retreat of the ice in Europe, temperatures rose rapidly, and by about 7,000 B.C. were several degrees above the present. This was the " climatic optimum ", when Europe was rapidly occupied by a mixed forest of oak, alder, lime and other warmth-loving trees, which extended their limits far to the north and far up the mountains. This warm period continued until nearly 2,000 B.C., after which the climate deteriorated.

There is no evidence that the Quaternary ice age is over ; in fact the occurrence and ending of the climatic optimum rather point in the opposite direction. It is possible that we are already in the second half of an interglacial, and that some thousands of years hence ice will again spread out from Norway and the Alps.

More remarkable than the temperature oscillations of the post-glacial period are the variations of rainfall. The late-glacial and early post-glacial were dry in Europe, in spite of the increasing warmth ; these are known as the pre-Boreal and Boreal periods. The next stage, the Atlantic period, was warm and rainy, and many of the peat-bogs began to form at this time. Peat mosses even grew in Spitsbergen, which is now too cold. Then followed an interval, the sub-Boreal, which has been the subject of much discussion. Peat-bogs dried up, lakes dwindled and there is every appearance of severe drought, but it is not clear whether this was a prolonged dry period lasting more than a thousand years, a short intense drought of a few centuries followed by conditions resembling the present, or merely an alternation of groups of dry and wet years. In fact, its existence has been denied altogether, but this extreme view is rare and hardly tenable. During the last part of the sub-Boreal conditions cannot have differed much from the present. This stage ended somewhere about 500 B.C. with the rather sudden onset of a cold wet period, the sub-Atlantic, which was severe at first but gradually passed into present-day conditions.

In other parts of the world the post-glacial sequence is not so well known as in Europe, though the climatic optimum appears to have been widespread if not world-wide, and there is evidence of a dry period in North America which may by roughly contemporaneous with the sub-Boreal. We must however spare a few words for climatic variations in the equatorial regions, which play a large part in several modern theories of climatic change.

The combined efforts of a number of investigators, especially L. S. B. Leakey, E. J. Wayland and E. Nilsson, have shown that in east Africa there have been a series of fluctuations of lake levels on a gigantic scale. The general succession is shown in Table II. Nilsson has further shown that the expansions of the lakes ran parallel with the expansions of the mountain glaciers, and it is probable

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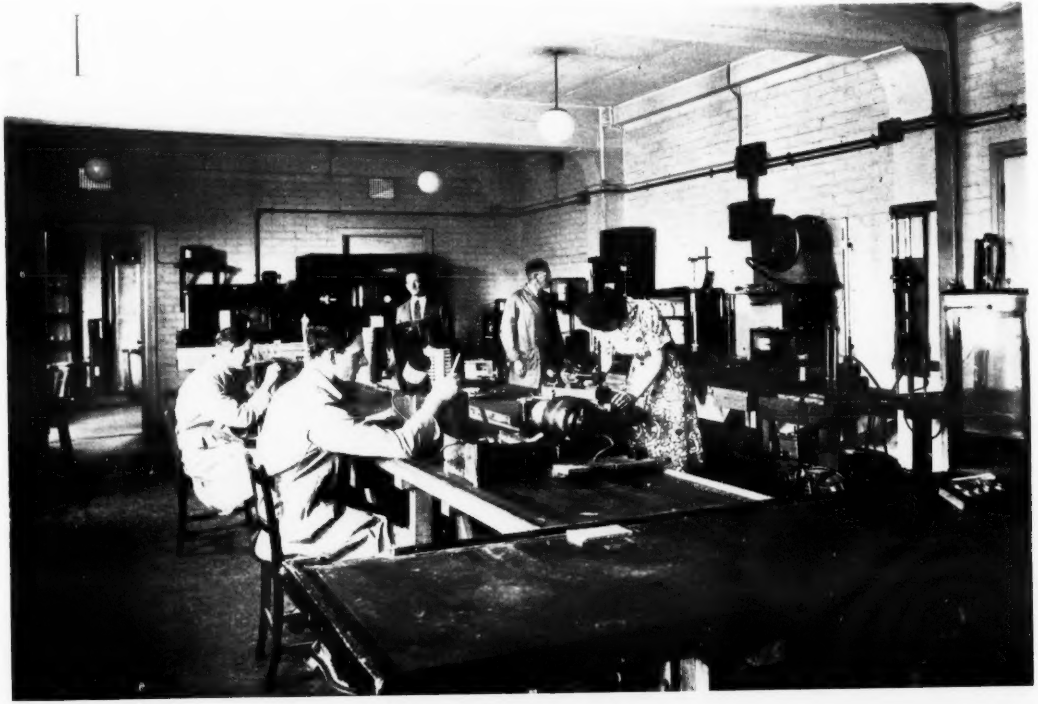
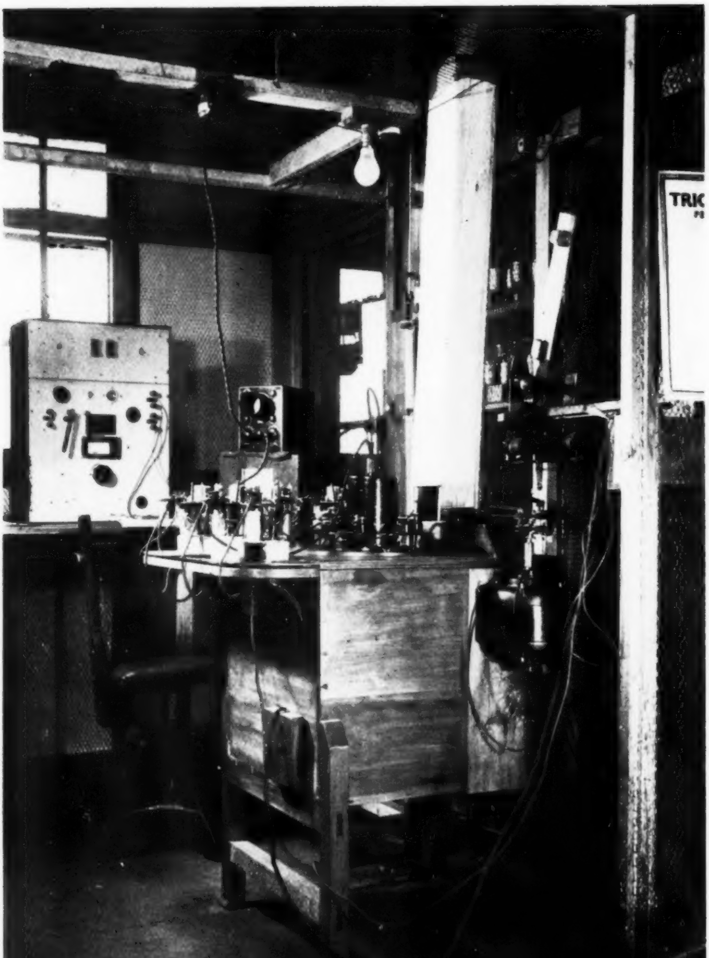


MAIN TEST ROOM AT HARROW

(see p. 124)



KEW-PATTERN RADIO-SONDE CALIBRATING PLANT

(see p. 125)

though not yet certain that the " pluvial " periods correspond roughly with the glaciations of higher latitudes.

TABLE II—SUCCESSION OF PLUVIAL AND INTERPLUVIAL PERIODS IN EQUATORIAL AFRICA

Post-pluvial	Alternating wet and dry phases Lakes dried up Wet phase Lakes dried up
Last pluvial (Gamblian)	Three extensions of lakes, separated by two periods of shrinkage
Interpluvial	Kamasia lake dried completely
Kamasian	Extremely wet and cold
Interpluvial ?	
Possibly an earlier pluvial	

A roughly similar succession has been found over most of the eastern half of Africa from the Nile Valley to Rhodesia.

When we turn to the historical period, in spite of a large amount of research, it is hard to come to definite conclusions about the reality and extent of climatic changes. Without going into details however, the results seem to be :—

(1) A generally dry period about A.D. 500 to 700 in Europe and much of Asia.

(2) A period of increased rainfall over most of Europe and Asia from about A.D. 1100 to 1250. This period was also very stormy in the North Sea, and there are indications that it was cold and stormy as far east as China.

(3) A marked advance of the glaciers in all parts of Europe beginning about A.D. 1600, followed by a series of oscillations until about 1850–1870, when a retreat set in which is still in progress. During this " little ice age " many glaciers are believed to have reached their greatest extent for over a thousand years. About 1600 also there began a rapid increase in the amount of pack-ice off Iceland.

Finally, instrumental observations during the past two centuries have shown that, even apart from isolated droughts, wet periods or severe winters, the general level of rainfall and temperature varies from one group of decades to another. The most notable example is the period of mild winters from about 1901 to 1930 which seems to have covered most of Europe and the Arctic, associated with a rapid retreat of the edge of the floating ice-cap. Such minor oscillations are however no monopoly of the present ; we find evidence of them wherever we can identify annual layers of sediment in the rocks. The sunspot cycle of 10–11 years for example seems to have persisted throughout geological time. The whole picture is one of an intricate series of superposed climatic variations, from gigantic swings over millions of years between ice ages and genial climates, all down the scale to changes of a few degrees between one decade and another and finally from year to year. In the second part we will discuss some of the theories which have been advanced to explain these changes.

(*To be continued.*)

GOLD VISIBILITY METER MK. II

BY J. R. BIBBY, B.A.

Introduction.—This instrument is based on a visibility meter designed by Mr. E. Gold, C.B., D.S.O., F.R.S.* and is used to measure the visibility at night. It is, in effect, a simple photometer used to measure the apparent brightness of a fixed lamp several hundred yards from the observer. This is done by observing the lamp through a graduated neutral filter which is varied until the lamp is only just visible. The meter reading then gives a measure of the transparency of the atmosphere, and by means of tables this can be related to the visibility which would be observed during daylight in an equally transparent atmosphere.

Description of the visibility meter.—The meter is illustrated in the photograph facing p. 136. The variable light filter A is cemented between glass plates approximately 20 cm. × 4 cm. which can slide in the main frame. The filter has the following properties :—

(*a*) It is neutral, i.e. it transmits light of all wave-lengths equally.

(*b*) It is almost completely transparent at one end, while at the other end it transmits only about 1/4,000 of the incident light.

(*c*) The variation of density along the filter is uniform in the sense that if the fraction of light transmitted is measured at a number of equidistant points along the filter, the figures for adjacent points will always be in the same ratio.

Two small neutral filters B (about 2 cm. square) are fixed to the frame of the instrument. These have the same uniform gradation of density as the main filter, but in the opposite direction. The superposition of a small filter on any part of the main filter therefore results in a uniform resultant density over the area of the small filter. One of these filters is nearly transparent, the other transmits only about 1/1,000 of the incident light. A moveable eyeshield C enables either of these filters to be used. The fraction of light transmitted varies (according to the position of the main filter) between about 1/2·5 and 1/4,000 if the clearer of the small filters is used, or between 1/2,500 and 1/4,000,000 if the denser filter is used.

The resultant opacity of the filters is indicated by two scales D fixed to the sliding filter, which move past two fixed marks E on the frame. The two scales, only one of which is visible in the photograph, correspond to the two alternative small filters, i.e. to the two positions of the eyeshield. The scales are graduated in terms of a special unit called a " nebule ", which is defined by the statement that a filter with an opacity of 100 nebules transmits 1/1,000 of the incident light. It follows that one nebule transmits 0·933 of the light falling on it.

The advantage of this unit lies in the fact that it represents approximately the smallest change in intensity which the eye can appreciate, and thus when using the meter the probable error of an observation by a careful observer will be of the order of one nebule. The range of the instrument expressed in nebules is from 15 to 120 for the clearer of the fixed filters, and from 115 to 220 for the

* See GOLD, E. ; A practical method of determining the visibility number *V* at night. *Quart. J. R. met. Soc., London*, **65**, 1939, p. 139.

denser filter. It follows from (*c*) that the nebule scales are linear (unit nebule divisions being about 1·7 mm. apart).

Method of using the meter.—First of all suitable lights must be selected. These may be specially installed, or existing lights may be used. The candle powers and distances may vary within fairly wide limits, but it has been found most convenient to have three 15 watt electric lamps, mounted on posts 2 m. high, at distances of 100, 500 and 1,500 m. from the observer. These lights should be white and, as far as possible, of constant intensity.

Having selected suitable lights, it is necessary to determine the visibility-meter reading when the lights are observed through the meter on a night of good visibility. This should be done immediately after dark on an evening when the visibility has been observed (during daylight) to be not less than about 20 Km., and when it is not expected to change much, e.g. when there is a fresh wind and a cloudy sky. These readings should be made on each light in turn, and by each observer separately, to allow for the differing sensitivity of different eyes. Full details of the procedure for making observations with the meter are given in Mr. Gold's paper, and are available in the Meteorological Office. Briefly, the observer should remain in darkness for five or ten minutes to allow his eye to accommodate itself to the darkness, and should then adjust the meter so that the light, as observed through it, is only just visible.

Having made these observations on a night of good visibility, tables or graphs (one for each observer and each light) can be prepared in the manner described in the next section. Then on subsequent nights the visibility may be measured by repeating the observation, but using only the most distant of the visibility lights which can be seen. If the visibility is less than on the previous occasion the meter reading will be lower, and the difference between the two (in conjunction with the tables or graphs described below) enables the visibility on the second occasion to be determined.

Relation between meter readings and equivalent daylight visibility.—Meter readings may readily be used to calculate the extinction coefficient of the air between lamp and observer as follows :—

The extinction coefficient μ is defined by the equation

$$I = I_0 e^{-\mu d}$$

where I is the apparent brightness of a lamp at distance d from the observer on the night in question, and I_0 its apparent brightness in perfectly clear air. If the visibility meter readings are n nebules for clear air and m nebules on the night in question, the apparent brightnesses as observed through the visibility meter are $I_0(0{\cdot}933)^n$ and $I_0 e^{-\mu d}(0{\cdot}933)^m$ respectively. But these must be equal, as they represent the faintest light visible to the eye, which is assumed constant. Thus we have

$$(0{\cdot}933)^n = e^{-\mu d}(0{\cdot}933)^m$$

$$\text{or} \qquad e^{-\mu d} = (0{\cdot}933)^{n-m}$$

Taking logarithms to base 10,

$$0{\cdot}4343\mu d = 0{\cdot}03(n-m),$$

$$\text{whence} \quad \mu = 0{\cdot}0691\,(n-m)/d$$

The relation between the extinction coefficient μ and the equivalent daylight visibility V cannot be directly calculated without making rather far-reaching

assumptions, and any formula resulting from such calculations must be verified experimentally before acceptance. The formula hitherto used with the Gold visibility meter (based on measurements by Bennett) is

$$\frac{n-m}{d} = \frac{134}{V^{1\cdot1}}$$

$$\text{i.e.} \qquad V = \left(\frac{134d}{n-m}\right)^{0\cdot91} \qquad ..(1)$$

This is equivalent to the relation

$$V = (9\cdot26/\mu)^{0\cdot91}$$

In all cases V and d must be in yards, and μ in yards $^{-1}$

Another relation between μ and V, due to Koschmieder, is now considered rather more accurate than Bennett's. Koschmieder's formula is usually expressed as $V = 3\cdot91/\mu$, but this refers to the (daylight) visibility of an object which is perfectly black and seen against the sky. As real objects are rarely perfectly black, and are sometimes seen against terrestrial backgrounds, the formula, $V = 3\ 75/\mu$ probably gives the best relation between μ and the visibility as normally estimated in daylight. For use with the visibility meter this formula may be written alternatively as :—

$$V = \frac{54\cdot3d}{n-m} \qquad ..(2)$$

In this case any unit of length may be used, provided that it is the same for V, d, and μ.

The differences between the formulae are negligible for visibilities above about 3,000 m. For lower visibilities the differences progressively increase, being about 20 per cent. at 1,000 m. and 50 per cent. at 100 m. Bennett's formula gives the higher values.

Whichever formula is used, the method of preparing conversion tables or graphs is similar. The reading n on a perfectly clear night must first be determined for each observer and each light. This is done by making observations on a night of known good visibility (as explained earlier), and by using formula (1), say, correcting for the non-infinite visibility by adding to the readings the quantity $54d/V$; i.e. if n_1 is the reading on a night of known visibility V then $n = n_1 + 54d/V$ where, as above, V is the visibility and d the distance of the lamp, in the same units. A series of graphs or tables (one for each observer and each light) can then be prepared, using equation (1) or (2), showing the relation between the meter readings and the visibility.

Accuracy obtainable.—It was stated above that the probable error of a single observation was about $\pm$ 1 nebule. The overall accuracy obtainable also depends, however, on errors arising from the following causes, which are quite independent of the small instrumental error ; errors from these causes would arise if the visibility were determined by direct observation on a series of lights extending to the limit of visibility :

(*a*) Variations in the sensitivity of the eye on different occasions.

(*b*) Random fluctuations in the brightness of the lamps (slow and regular changes in the lamps may be allowed for by repeating the measurements of n on every suitable night).

The probable errors due to these causes may be estimated as ± 5 nebules and ± 3 nebules respectively, and combining these with errors of ± 1 nebule in measuring both n and m, the overall probable error is about ± 6 nebules. It is seen from equation (2) that this corresponds to an error of about 11 per cent. when the visibility is the same as the distance of the light used, 22 per cent. when it is twice the distance, and 55 per cent. at five times the distance. It is clear, therefore, that only three well spaced lights are necessary to cover a range of visibilities from 100 m. to 5 Km. with reasonable accuracy, whereas without the visibility meter a more elaborate series of lights would be essential if the same accuracy were to be achieved. It must be remembered in this connexion that estimates of visibility made in daylight are subject to an uncertainty of roughly 20 per cent.

Two other possible sources of error may arise :—

(*a*) Uncertainty in the formula connecting μ and V.

(*b*) Lack of care in taking observations. It must be emphasised that carelessness in using the meter, especially neglect to allow time for the eye to accommodate itself to the darkness, may easily increase the errors by a factor of two or even three.

An improved visibility meter is being developed in the Meteorological Office with a view to eliminating some of the above sources of error. A more powerful light is used, and its apparent brightness is measured by means of a photo-electric cell.

HIGH-ALTITUDE SOUNDING BALLOONS

BY O. M. ASHFORD, B.SC. AND D. N. HARRISON, D.PHIL.

With the increasing activity in meteorological research in the stratosphere, the need for sounding balloons capable of carrying a useful load of 1 Kg. or more to a height of 100,000 ft. has become of considerable importance. The object of this note is to describe the development work on high-altitude balloons which is being carried out in this country under the supervision of the Instruments Branch of the Meteorological Office.

Sounding balloons are normally made in three sizes, 350 gm., 500 gm. and 700 gm. The average bursting height with a load of 1,500 gm. is in the region of 60,000 ft., but occasional ascents have been made to 75,000 ft. The main factors limiting the bursting height are the decrease in extensibility as the temperature falls, chemical action of oxygen and ozone and mechanical defects. Improvements might therefore be made (*a*) by using larger balloons or more than one balloon so that the elastic limit for a given load would not be reached until a greater height, (*b*) by using better antioxidants and/or dyes in the rubber mix, (*c*) by using materials other than natural rubber or (*d*) by using a valving technique to allow some hydrogen to escape when the internal pressure becomes too great.

It was estimated by the Research and Development Establishment, Cardington, that a balloon weighing 10 Kg., capable of expanding to 40 ft. diameter, would be necessary to carry a load of 1 Kg. to 100,000 ft. with reliability. As a step in this direction, the Guide Bridge Rubber Co. produced six balloons weighing 4,500 gm., four of which were flown at Larkhill with the results shown in Table I. The bursting heights, which were measured by radar,

were variable, but the average of 71,000 ft. is appreciably greater than for smaller balloons. The last of these four gave a particularly interesting ascent. It passed out of range of the radar set at a height of 83,900 ft., while still rising. The remnants of the balloon and the radar target which it carried, were found an hour or so later at Brookham, near the Dorking-Reigate road. From the distance travelled it was deduced that the balloon must have reached a height of more than 100,000 ft. Further experiments are being made.

TABLE I—ASCENTS WITH 4,500 GM. BALLOONS

Weight carried	Free lift	Height burst	Rate of ascent to 40,000 ft.	Remarks
Kg.	Kg.	ft.	ft./min	
1·9	5·5	80,100	1,420	Radio-sonde carried in addition to radar reflector
1·2	5·0	45,000	1,400	—
1·2	3·5	58,500	1,310	—
1·2	2·5	(100,000)	800	Maximum height measured : 83,900 ft., when range too great for radar. Balloon found at Brookham, Surrey, and height of 100,000 ft. deduced from data.

To obviate the difficulty in tying two ordinary balloons together without the risk of the string chafing the rubber, the Guide Bridge Rubber Co. produced some special 700 gm. balloons with two diametrically opposite necks. Twenty-four of these balloons were flown at Larkhill, with the results shown in Table II.

TABLE II—ASCENTS WITH BALLOONS IN TANDEM

Ascent No.	Bursting height	Remarks
	ft.	
1	49,000	Lower balloon burst first
2	51,000	
3	64,000	
4	>66,000	
5	74,000	
6	53,000	Radio-sonde switch stuck on temperature or humidity element with little subsequent change. Probable that upper balloon burst first and lower balloon remained floating
7	56,000	
8	69,000	
9	76,000	
10	83,000	
11	>66,000	Switch stuck ; windmill started turning again after burst — Reading of 78,000 ft. on descent
12	>73,000	Switch stuck ; windmill started turning again after burst — Reading of 93,000 ft. on descent
13	>67,000	Burst not observed ; radio-sonde failure
14	64,000	Two double-necked balloons used
15	71,000	Balloons joined by tube to equalise pressure

The ascents are grouped according to the nature of the termination, not chronologically. Except in ascent No. 14, the upper balloon was the normal 500 gm. type ; free lift of upper balloon normally 2,200 gm. and of lower balloon 2,000 gm.

Unfortunately, radar observations could not be made, and the bursting heights had to be estimated from radio-sonde readings. It was found that at extreme heights the windmill operated switch of the Meteorological Office radio-sonde does not function satisfactorily. The results were somewhat erratic but appreciably greater heights than usual were obtained on 11 of the 15 useful

ascents. With the tandem balloons there are several possible variations in technique, e.g. upper balloon with greater free lift than lower, pressures equalised between balloons by connecting tube, etc., and it is considered that further experiments will lead to profitable results.

In tests made during the war, the Research and Development Establishment had found that balloons coloured with a special orange dye withstood exposure to daylight much longer than other balloons. A batch of seventy orange balloons was tested at Downham Market, but the bursting heights were if anything slightly lower than those obtained with white balloons, both by day and by night.

The obvious alternatives to natural rubber are artificial rubber and non-extensible materials such as that used by Dr. Regener*. Of the artificial rubbers, neoprene is best for meteorological balloons, and the Americans claim to have made some capable of reaching 100,000 ft.† Neoprene latex is not made in this country and there are practical technical difficulties in transporting it from America. No immediate experiments can therefore be made over here, other than with American balloons.

The non-extensible materials used by Regener are being examined and it is possible that some may be made in this country. The non-extensible balloons suffer from the disadvantage that they have to be very much larger at the start than ordinary balloons.

VARIATIONS OF TEMPERATURE IN LONDON, 1764–1939

BY L. F. LEWIS, M.SC.

This article, which was completed early in 1940, was written at the suggestion of the late Mr. Joseph Baxendell.

Much interest has been shown by meteorologists in recent years in the apparent upward trend of temperature in the northern hemisphere. In an examination of the long and reliable record of the Radcliffe Observatory, Oxford[1]‡, the writer[2] found that the curve of 20-year moving averages of mean annual temperature was a periodic one, and although the maximum now being experienced has extended over a long period of years it is less pronounced than the one indicated in the early part of the nineteenth century ; this suggested that the mildness of the first part of the twentieth century did not necessarily denote a change of climate but only a rather prolonged mild phase.

Dr. C. E. P. Brooks has collected and tabulated a series of mean temperatures for London from 1764 ; these are published in a paper by Professor D. Brunt[3], and at the request of the late Mr. J. Baxendell of Southport, curves (see Fig. 1) similar to those for Oxford, showing the variations of 20-year moving averages of mean temperature for summer (June to August), winter (December to February), and for summer minus winter (see Fig. 2) were prepared for a period back to 1764 by Mr. G. A. Tunnell, of the Meteorological Office. Later, a curve showing variations of annual mean temperature was also prepared (see Fig. 1). Each point on these curves represents the average temperature for the

* REGENER, E. ; Ballone mit grosser Steiggeschwindigkeit und Thermograph von geringer thermischer Trägheit. Schriften der Deutschen. Akademie der Luftfahrtforschung, Berlin. Heft 37, 1943.

† SPILHAUS, A. F. ; Recent developments in meteorological equipment. *Bull. Amer. met. Soc., Milton Mass.*, **27**, 1946, p. 399.

‡ The list of references is on p. 138.

20 years ending on the year shown by the abscissa of the point. The London observations of temperature are not a homogeneous series throughout ; from 1841 they represent observations at Greenwich Observatory and are reliable

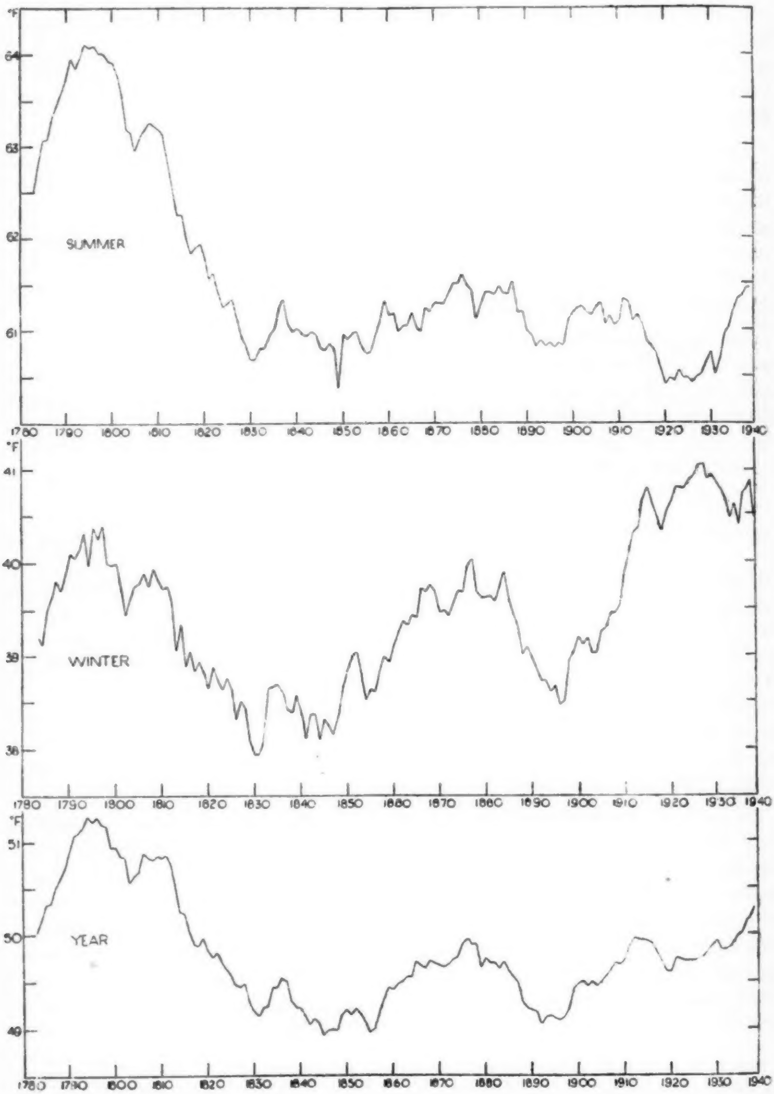
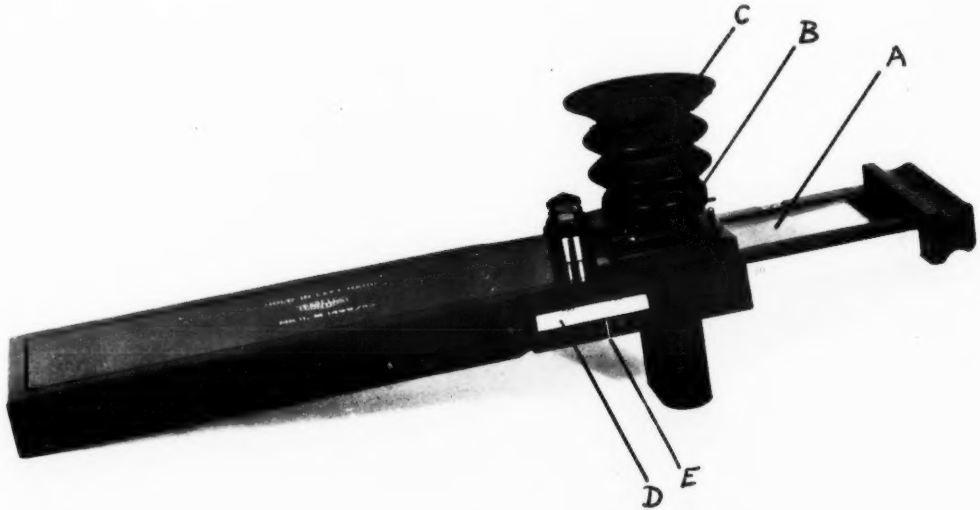


FIG. I—TWENTY-YEAR MOVING AVERAGES OF MEAN TEMPERATURE AT GREENWICH

[To face page 136



GOLD VISIBILITY METER, MK. II

(see p. 130)

To face page 137]

R.A.F. Photograph

OROGRAPHIC CLOUD OVER ST KILDA, MAY 5, 1942

and homogeneous but, in the earlier years, the site and exposure of the instruments varied from time to time and the observations are therefore less reliable for purposes of comparison. The curve of 20-year moving averages of mean annual temperature shows two minima and three maxima during the whole period ; the periods between the two minima and possibly the two later maxima is roughly 50 years, but the first maximum occurs approximately 75 years before the second. This first maximum, which occurred during the end of the eighteenth and beginning of the nineteenth centuries is more pronounced than the other two. Turning to the seasonal curves, the curve representing the variation for the three winter months is broadly similar to that for the year.

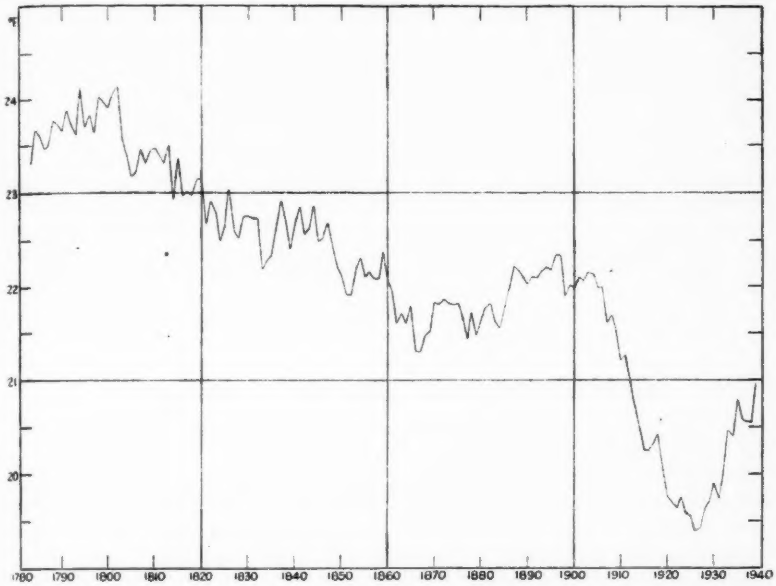


FIG. 2—TWENTY-YEAR MOVING AVERAGES OF MEAN SUMMER TEMPERATURE MINUS MEAN WINTER TEMPERATURE AT GREENWICH

The curve is not so smooth but the maxima and minima occur around the same periods ; in the winter curve, however, the maximum occurring in the first part of the twentieth century is the most pronounced, while in the annual curve that occurring at the end of the eighteenth and beginning of the nineteenth centuries is the most important. The summer curve shows no relation to the other two during the latter part of the period ; in fact, there is a minimum during the first thirty years of the present century instead of the considerable maximum shown at this time during the winter season. The exceptional maximum which occurs during the early years of the period under consideration in the summer months may, in part, be due to changes in exposure and site of the instruments referred to above, but with regard to the unusual warmth of these years the data given in a paper by Dr. C. E. P. Brooks and Miss T. M. Hunt[1] on variations of wind direction since 1341 is of interest. The authors

show that in London the period 1792–1810 was one of remarkably steady southerly winds ; after this period the direction became progressively more we terly. It is well known that in summer southerly winds bring high temperatures in south-east England. From 1901–30 the resultant winds in summer were from WSW., the most westerly of all the periods analysed since 1651 ; this is in good agreement with the cool summers experienced during this time.

The curve in Fig. 2 represents 20-year moving averages of mean summer temperature minus mean winter temperature and shows the unusually equable conditions experienced in south-east England during the first quarter of the twentieth century. This curve indicates perhaps the most marked change in temperature conditions during the period under consideration ; there are minor fluctuations but on the whole it shows a fairly steady decrease in " annual range " of temperature, with a rapid decrease in the early decades of the twentieth century. The last part of the curve, however, shows a partial recovery.

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3. BRUNT, D. ; Periodicities in European weather. *Philos. Trans., London,* **225**, Series A, 1925, p. 247.
4. BROOKS, C. E. P. and HUNT, T. M. ; Variations of wind direction in the British Isles since 1341. *Quart. J. R. met. Soc., London,* **59**, 1933, p. 375.

METEOROLOGICAL RESEARCH COMMITTEE

The 48th meeting of the Meteorological Research Committee was held at the Meteorological Office, Harrow, on Thursday, May 8, 1947.

The papers considered included a review of progress in the development of meteorological instruments, two papers on the accuracy of radar methods of wind measurement, a note on balloon soundings up to a height of 30 Km., and a paper on the prediction of evaporation from saturated surfaces.

ROYAL METEOROLOGICAL SOCIETY

On May 14, Professor C. Störmer gave a lecture on " mother-of-pearl clouds " to the Royal Meteorological Society. These interesting clouds, which are occasionally seen in Norway before sunrise or after sunset, were shown to be associated in some cases with a depression north of Norway. They can be observed under f. hn conditions, when other cloud is absent. By using cameras designed for work on aurora the height of mother-of-pearl clouds has been measured. Usually they are at 25–30 Km., but they have been observed as low as 12–14 Km., and as high as 33 Km. On the two occasions when it was possible to determine the temperature at about the level of the clouds, it was found to fall to −75°C. and −83°C. On another occasion, photographs revealed that the air was in violent turbulence at the cloud level of 26–28 Km. The clouds are formed of very small water drops about 2μ in diameter.

Professor Störmer showed some very effective coloured slides and the occasional applause from Fellows showed that many of them were appreciating for the first time the beauty of these clouds.

An interesting discussion followed the lecture, in which most of the speakers had to put their remarks in the form of questions. Among the speakers were Dr. Stagg who asked whether the clouds moved, and how the water was able to reach such heights. Professor Sheppard asked whether it was possible that the closed isobar pattern extended up to those great heights on occasion, so that a sufficiently steep pressure gradient might lead to inflowing motion and ascent. Dr. Goldie pointed out that in the winter the air at 24–25 Km. north of about 60°N. has an upward motion on the average, particularly when a depression is north of 60° N. ; horizontally, the air has a poleward component and it is probably more or less saturated. Mr. Brewer mentioned the very low humidity of the stratosphere and pointed out that Professor Störmer's results showed that sometimes the temperature in the stratosphere must fall at great heights. Sir Charles Normand asked whether there were in fact more mother-of-pearl clouds over Norway than over the British Isles ; he pointed out that in the present state of our knowledge we could postulate movement of the air in almost any direction as necessary to the formation of these clouds, and suggested that the mountains of Norway might produce atmospheric waves. Mr. Ashford emphasised this last point by mentioning reports from German glider ascents, which showed that there are waves in the stratosphere, especially under föhn conditions ; he added that we have so far only a few observations of humidity in the stratosphere, and these chiefly on occasions of low tropopause ; humidity may not be low in all circumstances.

Professor Störmer replied briefly to some of the points which had arisen in the discussion. In conclusion, the President, Dr. Dobson, asked why the clouds are found at limited levels if they are due to rising currents, and how turbulence can occur at such heights. He pointed out that ozone observations showed that some fronts extend into the stratosphere, and wondered whether this fact was related to the mother-of-pearl clouds. The photographs suggested that the clouds were of two kinds since some showed definite lenticular formation and others indicated turbulent motion.

LETTER TO THE EDITOR

An account of the development of cumulus over a tar fire at Changi on March 1, 1947

This account is based on a log made at the time and a detailed description, including the evidence of five witnesses, written the same day by F/Lt. Craddock. Times are thought to be correct within one minute.

On the morning of March 1, 1947, F/Lt. Craddock went to the top of the water tower near Station Sick Quarters, Changi, to study cloud formation. At 1035, looking almost due south, he noticed black smoke rising from near the Changi runway (which is out of sight behind an eminence). The smoke rose in a dense, narrow column, which showed no inclination across the line of sight. Its form suggested a very elongated tree, and there was no sign of spin about a vertical axis. At about 1040 he noticed that the top of the column had a peculiar greyish appearance, and almost at once saw that condensation was taking place. At 1041 it was clear that the top of the smoke column had turned into a compact cumulus, which he tried unsuccessfully to photograph. He did however observe and log that the smoke column exactly filled the reflex view finder of the camera, which has a field of $33\frac{1}{2}°$.

By 1044 the cumulus was quite well developed, and by 1050 the smoke column had dispersed, leaving a roughly spherical cumulus cloud, which drifted away to the north. F/Lt. Craddock had been examining that part of the sky since 1030 and it was perfectly clear to him that the cumulus had formed from the top of the smoke column. The sun was shining in an almost clear sky, and felt very hot, and the surface wind was imperceptible.

At the same time F/Lt. Smith was by the Changi runway making nephoscope observations, and saw the fire about a quarter of a mile to the west. He observed that the smoke column rose vertically and saw the cumulus form on top. The fire was in and around a tar boiler which had just been refilled with two barrels of tar, and it appeared that about one barrel of tar had actually been burnt. Estimates of the width of the smoke column near the base ranged from 10 to 24 ft. with 18 ft. probably about right. All witnesses described it as " very narrow ".

The water tower is $1,800 \pm 20$ yds. from the site of the fire, so that the height of the column at 1041 was approximately 3,580 ft. The rate of ascent was therefore almost 600 ft./min.

This incident shows :—

(1) that in favourable conditions the amount of heat energy which must be released to start cumulus formation may be very small.

(2) that a rising thermal current originating within a few feet of the ground may continue its ascent although perhaps in a diluted state until the condensation level is reached, even though the current starts with a linear diameter as small as 18 ft., and has no apparent spin.

W. H. SMITH
J. M. CRADDOCK

Changi, Singapore, April 22, 1947.

NOTES AND NEWS

Meteorological Association

The first annual reunion of the Association will take the form of a Supper Dance to be held on November 1, 1947, at the Royal Empire Society in Craven Street, near Northumberland Avenue. A section of the Royal Air Force Dance Band has been engaged to provide the music. Tickets will cost 10s. each, and may be obtained after September 1 from the Treasurer, 238 Sheen Lane, London, S.W.14. Dress is optional.

Functional English

Professor R. O. Kapp has recently given a series of four lectures on " The presentation of technical information " in which he introduced the idea of functional English and pointed out the reasons for some of the common faults in technical literature. The following general account of the lectures has been prepared, as the subject is of unusual importance to meteorologists who, because of the public interest in the results of their work, have to pay particular attention to the presentation of technical information. This report however, is not intended to be a complete summary of the lectures.

Functional English can be defined as the language which should be used to convey new information from mind to mind. This information may be

presented in many different ways, e.g. as a report to a senior officer, as a written or spoken instruction to a junior, or as a paper to a learned society. The language used will vary with the type of information and with the identity of the persons addressed, but unless it induces receptivity in these persons it is not functional. Language used for all other purposes can be described as imaginative English, and a good functional style cannot be acquired merely by a study of good classic styles, for so much of the effectiveness of the best imaginative literature depends upon allusion, which should be absent from functional writing. The contrast between the styles can be summarised by describing functional English as the language of inspection and imaginative English as the language of introspection ; for full understanding, the one makes demands upon the recipient's reason and the other upon his insight. Functional English should always be simple and clear, and generally concise, but imaginative English may be vague and repetitive.

The problems to be overcome in presenting technical information are :—

(i) Linguistic,
(ii) Logical,
(iii) Psychological, including (*a*) association, (*b*) understanding, (*c*) memorising.

The linguistic problem involves the elimination of everything which interferes with the smooth flow of thought and includes the avoidance of vague or unfamiliar phrases, tortuous syntax, and ugly sounds or rhythms.

To be satisfactory logically the exposition should not contain unfamiliar ideas unless these are clearly and logically connected with ideas familiar to the recipient ; significant facts or figures should have their significance explained, and there should be no emphasis on matters of secondary importance.

Language can only be psychologically effective when the expositor is acutely aware of the person addressed, so that he can realise the extent of his knowledge and his capabilities of understanding. A good expositor will make it easy for the recipient to bring the new knowledge into association with his previous knowledge, to understand the new knowledge and to memorise it. In order to achieve the maximum effectiveness of association, understanding and memorising, the presentation of the information must be carefully timed, so that the recipient may be stimulated to put forward his greatest effort. Professor Kapp suggested that his classes should study the technique of a first-class music-hall comedian, who is necessarily a master in the art of timing so as to stimulate and maintain the interest of his audience.

It should not be inferred from what has been written that these lectures were concerned only with general principles. Professor Kapp passed on a number of practical hints, of which a few are given below.

A report on a given subject is usually meant to influence the actions of a reader ; a book or a paper is meant to influence his thought. In a report, details of experimental methods may thus often be omitted, but in a paper they should generally be included.

Tables (e.g. of data or results) may be regarded as basic knowledge, and text as assimilated knowledge. Text is therefore often necessary in addition to tables.

It is possible to be too concise. Enough words should be used to convey the information from mind to mind, though these are often far more than suffice

merely to put the information on record. It is important to avoid meaningless phrases. They bore the recipient and make him less receptive.

It may be necessary to state the obvious, especially when the information is numerical, e.g. the quoted value is " high " or " low ". Words of comment such as " even ", " surprisingly ", etc., are useful to understanding.

The writer of functional English must explain and not imply, the reasoning must be done for the reader and not by the reader. Graphical presentation should be freely used, but care should be taken to avoid including on the graphs more material than is absolutely necessary.

Circumlocutions such as " in the case of ", " with reference to " are occasionally justifiable, but they are usually thought-dodging devices.

It is useful to read a manuscript some little while after it has been written.

Qualifications of statement should be avoided where possible and a qualification should never be put within a qualification. In illustrating these points, Professor Kapp provided examples of non-functional English from technical literature (including one from his own writing).

Probably the main value of these lectures lay in the logical basis on which Professor Kapp has built his conception of functional English. Using this basis it is possible to ask whether a particular piece of writing is functional or not, and to discover in what way it fails to achieve its object. Professor Kapp would not claim that his basis will necessarily be the best, but it is a great advance to have any standards by which to judge the adequacy of the presentation of technacil information.

W. H. HOGG

REVIEW

A comparison of Cherat surface observations of temperature and humidity at 0800 *hrs. L.T. with aeroplane observations over Peshawar plain at the same level*, by K. L. Bhatia. Scientific Notes of the India Meteorological Department. Vol. X, No. 116. 4to., 10½ in. × 7 in., pp. 11–17, Delhi, 1942. Annas 6 or 7*d*.

This paper concerns a subject which is of considerable interest to people studying conditions near the surface of the earth. In this case it is the influence of the mountain surface on the free air.

Observations at Cherat Observatory (33° 50'N., 72° 01' E. height : 3 Km.) at 0800 local time have been compared with aeroplane ascents carried out near the observatory (about 20 miles away). In a total of 449 observations of free air temperature minus mountain air temperature, approximately evenly distributed throughout the year, it is found that the majority of observations are clustered round the mean value. This value is in general positive which is in agreement with other writers. Relative humidity and for most of the year vapour pressure are both higher over the mountain than in the free air. This indicates that during most of the year there is a flow of moisture from the mountain to the free air. The greatest differences come during the wetter months when one would expect the greatest amounts of evaporation. This paper would be of greater interest if the data were of more general application and could be used for mountains in general.

G. A. TUNNELL

RAINFALL OF APRIL, 1947

Great Britain and Northern Ireland

County	Station	In.	Per cent of Av.	County	Station	In.	Per cent of Av.
London	Camden Square	1·87	121	*Glam.*	Cardiff, Penylan	3·13	125
Kent	Folkestone, Cherry Gdns.	1·73	104	*Pemb.*	St. Ann's Head	3·38	165
,,	Edenb'dg, Falconhurst	2·15	115	*Card.*	Aberystwyth	1·76	86
Sussex	Compton, Compton Ho.	2·95	147	*Radnor*	Bir. W. W., Tyrmynydd	4·86	132
,,	Worthing, Beach Ho.Pk.	1·32	85	*Mont.*	Lake Vyrnwy	7·00	217
Hants	Ventnor, Roy. Nat. Hos.	2·01	120	*Mer.*	Blaenau Festiniog	7·81	126
,,	Fordingb'dg, Oaklands	2·88	157	*Carn.*	Llandudno	2·94	174
,,	Sherborne St. John	2·33	132	*Angl.*	Llanerchymedd	4·28	194
Herts.	Royston, Therfield Rec.	2·01	128	*I. Man.*	Douglas, Boro' Cem.	4·47	183
Bucks.	Slough, Upton	1·66	116	*Wigtown*	Pt. William, Monreith	4·32	196
Oxford	Oxford, Radcliffe	1·84	115	*Dumf.*	Dumfries, Crichton R.I.	5·72	242
N'hant.	Wellingboro', Swanspool	2·10	141	,,	Eskdalemuir Obsy	10·02	295
Essex	Shoeburyness	1·08	89	*Roxb.*	Kelso, Floors	3·94	251
Suffolk	Campsea Ashe, High Ho.	1·26	89	*Peebles*	Stobo Castle	6·73	322
,,	Lowestoft Sec. School	1·38	93	*Berwick*	Marchmont House	3·43	170
,,	Bury St. Ed., Westley H.	2·00	131	*E. Loth.*	North Berwick Res.	2·22	158
Norfolk	Sandringham Ho. Gdns.	2·06	136	*Midl'n.*	Edinburgh, Blackfd. H.	2·92	199
Wilts.	Bishops Cannings	2·32	150	*Lanark*	Hamilton W. W., T'nhill	5·53	296
Dorset	Creech Grange	2·45	113	*Ayr*	Colmonell, Knockdolian	4·23	167
,,	Beaminster, East St.	3·07	130	,,	Glen Afton, Ayr San	9·17	306
Devon	Teignmouth, Den Gdns.	2·80	139	*Bute*	Rothesay, Ardencraig	5·65	190
,,	Cullompton	1·95	86	*Argyll*	Loch Sunart, G'dale	7·90	189
,,	Barnstaple, N. Dev. Ath.	2·87	135	,,	Poltalloch	4·61	153
,,	Okehampton, Uplands	5·52	173	,,	Inverary Castle	10·38	226
Cornwall	Bude School House	1·90	101	,,	Islay, Eallabus	4·50	157
,,	Penzance, Morrab Gdns.	2·87	118	,,	Tiree	5·83	237
,,	St. Austell, Trevarna	3·09	110	*Kinross*	Loch Leven Sluice	4·51	235
,,	Scilly, Tresco Abbey	2·29	117	*Fife*	Leuchars Airfield	2·28	144
Glos.	Cirencester	2·62	140	*Perth*	Loch Dhu	14·87	314
Salop.	Church Stretton	2·86	131	,,	Crieff, Strathearn Hyd.	7·55	345
,,	Cheswardine Hall	2·24	128	,,	Blair Castle Gardens	4·92	233
Staffs.	Leek, Wall Grange P.S.	2·74	133	*Angus*	Montrose, Sunnyside	2·94	161
Worcs.	Malvern, Free Library	2·57	143	*Aberd.*	Balmoral Castle Gdns.	3·91	182
Warwick	Birmingham, Edgbaston	2·64	152	,,	Aberdeen Observatory	1·96	105
Leics.	Thornton Reservoir	2·22	131	,,	Fyvie Castle	1·82	85
Lincs.	Boston, Skirbeck	1·82	135	*Moray*	Gordon Castle	1·29	74
,,	Skegness, Marine Gdns.	1·78	133	*Nairn*	Nairn, Achareidh	1·44	103
Notts.	Mansfield, Carr Bank	2·30	138	*Inv's*	Loch Ness, Foyers	8·80	406
Ches.	Bidston Observatory	2·42	149	,,	Glenquoich	21·08	325
Lancs.	Manchester, Whit. Park	2·37	123	,,	Ft. William, Teviot	12·44	276
,,	Stonyhurst College	3·41	126	,,	Skye, Duntuilm	8·38	258
,,	Blackpool	3·39	180	*R. & C.*	Ullapool	4·54	150
Yorks.	Wakefield, Clarence Pk.	1·98	118	,,	Applecross Gardens	7·11	208
,,	Hull, Pearson Park	1·46	94	,,	Achnashellach	12·05	225
,,	Felixkirk, Mt. St. John	2·92	175	,,	Stornoway Airfield	5·66	197
,,	York Museum	1·73	108	*Suth.*	Lairg	3·22	139
,,	Scarborough	1·97	126	,,	Loch More, Achfary	10·11	208
,,	Middlesbrough	2·85	208	*Caith.*	Wick Airfield	1·81	91
,,	Baldersdale, Hury Res.	6·52	269	*Shet.*	Lerwick Observatory	4·24	185
Nor'd.	Newcastle, Leazes Pk.	3·16	199	*Ferm.*	Crom Castle	3·19	125
,,	Bellingham, High Green	5·44	252	*Armagh*	Armagh Observatory	3·60	171
,,	Lilburn Tower Gdns.	4·53	229	*Down*	Seaforde	3·55	135
Cumb.	Geltsdale	4·26	200	*Antrim*	Aldergrove Airfield	2·99	142
,,	Keswick, High Hill	11·86	386	,,	Ballymena, Harryville	3·98	151
,,	Ravenglass, The Grove	4·39	177	*Lon.*	Garvagh, Moneydig	4·45	182
Mon.	Abergavenny Larchfield	4·83	191	,,	Londonderry, Creggan	4·53	176
Glam.	Ystalyfera, Wern Ho.	6·30	166	*Tyrone*	Omagh, Edenfel	4·43	168

WEATHER OF APRIL, 1947

The greater part of April was characterised by depressions travelling eastwards or north-eastwards across the British Isles or between Iceland and Scotland. Some of these reached considerable intensity, pressure in the centres falling below 964 mb. on the 6th, 960 mb. on the 14th and 956 mb. on the 21st. Pressure was generally high over France, and south-westerly winds prevailed over the British Isles, with mostly mild, sunny and pleasant weather in south-west England but excessive rainfall in Scotland. The best period was from the 9th to the 17th when conditions over England were mainly anticyclonic. Over the month as a whole the mean pressure ranged from 998 mb. at Reykjavik in Iceland to 1024 mb. at Nantes on the west coast of France, and there was a steep gradient for SW. winds over Great Britain.

Differences from average showed a large area of 10 mb. or more below normal, extending from Spitsbergen to south-east Greenland and the Gulf of Finland, and an anticyclonic belt from Bermuda to the Black Sea, over most of which pressure was 5–10 mb. above normal.

The deviation from the average mean pressure over the British Isles ranged from −5.0 mb. at Lerwick to +5.1 mb. at Lympne. The gradient was greatly increased above the average, the pressure chart being comparable with the normal chart for January. Winds from between S. and W. predominated and in all areas the total run of the wind exceeded the average ; at Lerwick, the average wind velocity was as high as 20 m.p.h. Gales occurred very frequently for the time of year, the stormiest periods being the 5th–8th and 20th–25th. The gale on the 23rd was unusually severe in England and Wales, the wind gusting to 88 m.p.h. at Aberporth, 87 m.p.h. at Bidston and 86 m.p.h. at Manchester (Ringway) on that day. The month was very wet on the whole ; in Scotland it was the wettest April in a record going back to 1869. More than three times the average occurred over much of central and south Scotland and over a small part of Cumberland. Less than the average was received in part of a coastal strip from Aberdeen to Wick, in the Thames Estuary, on the Suffolk coast and at a few scattered places chiefly in the south of England. Temperature somewhat exceeded the average especially in eastern districts ; the first four or five days and the closing days were rather cold and the remainder of the month mild on the whole, particularly the period 12th to 17th. Broadly speaking sunshine exceeded the average in eastern districts of England and was below the average at most places elsewhere.

The general character of the weather is shown by the following table :—

	Air Temperature			Rainfall		Sunshine	
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days' difference from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
England and Wales ..	73	22	+1·5	143	0	102	37
Scotland	66	20	+0·7	215	+5	83	27
Northern Ireland ..	61	24	+1·2	156	+3	85	31